INDOOR AIR QUALITY ASSESSMENT

Mary K. Goode Elementary School
31 Mayflower Avenue
Middleborough, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Bureau of Environmental Health Assessment
Emergency Response/Indoor Air Quality
January 2005

Background/Introduction

At the request of Dr. Robert Sullivan, Assistant Superintendent, Middleborough Public Schools, the Massachusetts Department of Public Health (MDPH), Center for Environmental Health's (CEH) Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality at the Henry B. Burkland Intermediate/Mary K. Goode Elementary School Complex (BIS/GES), 41 Mayflower Avenue, Middleborough, Massachusetts. On June 2, 2004, a visit to conduct an indoor air quality assessment was made to the BIS/GES Complex by Cory Holmes, an Environmental Analyst in BEHA's Emergency Response/Indoor Air Quality (ER/IAQ) Program. Concerns about mold and other indoor air quality issues prompted the request.

The GES and BIS are both part of a three building complex. The BIS is in the northeastern section of the complex (Map 1). The GES is in the southwestern section of the complex. Both the BIS and GES share the central building of the complex, North and Central House. Hallways connect each of the building sections to other portions of the complex. The GES is the subject of this report. The BIS and the North/Central house building will each be the subject of separate reports.

Methods

BEHA staff performed visual inspection of building materials for water damage and/or microbial growth. Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were conducted with the TSI, Q-Trak, IAQ Monitor, Model 8551. Air tests for airborne particle matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. Screening for total volatile organic compounds was conducted using a Thermo Environmental Instruments Inc., Model 580 Series Photo Ionization Detector (PID).

Results

The GES houses approximately 530 students in grades 1 and 2 with approximately 65 staff members. Tests were taken during normal operations and results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were elevated above 800 parts per million (ppm) in five of thirty areas surveyed, indicating adequate ventilation in the majority of areas surveyed. However, it is important to note that many components of the mechanical ventilation system were deactivated. During the assessment, a number of classrooms were sparsely occupied and/or had open windows, which can greatly reduce carbon dioxide levels. With increased occupancy and closed windows (e.g., during the heating season), carbon dioxide levels in classrooms would be expected to be higher.

Fresh air is supplied to classrooms by a unit ventilator (univent) system (Picture 1). A univent draws air from outdoors through a fresh air intake located on the exterior wall of the building (Picture 2) and returns air through an air intake located at the base of the unit (Figure 1). Fresh and return air are mixed, filtered, heated and provided to classrooms through an air diffuser located in the top of the unit. A number of univents were deactivated during the assessment (Table 1). Obstructions to airflow, such as papers and books stored on univents and items placed in front of univent returns, were seen in a number of classrooms (Picture 3). In order for univents to provide fresh air as designed, these units must remain activated and allowed to operate while rooms are occupied. In addition, univent intakes and diffusers must remain free of obstructions.

Mechanical exhaust ventilation is powered by rooftop fans. Exhaust vent grilles are located in the ceilings of coat closets (Picture 4). Air is drawn into the classroom coat closet via undercut doors (Picture 5). The exhaust system was either not functioning or drawing weakly in several areas surveyed, indicating that motors were deactivated or non-functional (Table 1). The location of these vents inside closets allows them to be easily blocked by stored materials (Pictures 6 and 7), thereby restricting airflow. As with the univents, exhaust vents must be activated and remain free of obstructions in order to function as designed. Without sufficient supply and exhaust ventilation, environmental pollutants can build up, leading to indoor air quality/comfort complaints.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that HVAC systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). The date of the last balancing of these systems was not available at the time of the assessment.

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or openable windows (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, see Appendix A.

Temperature measurements ranged from 73^{o} F to 80^{o} F, which were above the BEHA comfort range in a number of areas (Table 1). The BEHA recommends that indoor air temperatures be maintained in a range of 70^{o} F to 78^{o} F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. In addition, it is difficult to control temperature and maintain comfort without operating the ventilation equipment as designed (e.g., univents and exhaust vents deactivated/obstructed).

The relative humidity measurements in the building ranged from 46 to 58 percent, which were within the BEHA recommended comfort range. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Signs of bird roosting and nesting were observed in a number of recesses around the building exterior (e.g., overhangs, building envelope penetrations for downspouts/roof drains) (Pictures 8 and 9). Birds can be a source of disease, and bird wastes and feathers can contain mold, which can be irritating to the respiratory system.

Certain molds associated with bird waste are of concern for immune-compromised individuals. Other diseases of the respiratory tract may also result from chronic exposure to bird waste. Exposure to bird wastes is thought to be associated with the development of hypersensitivity pneumonitis in some individuals. Psittacosis (bird fancier's disease) is another condition closely associated with exposure to bird wastes in either the occupational or bird rearing setting. While immune-compromised individuals have an increased risk of health impacts following exposure to the materials in bird wastes, these impacts may also occur in healthy individuals exposed to these materials.

The methods employed for cleaning of a bird waste problem depend on the amount of waste and the types of materials contaminated. The MDPH has been involved in several indoor air investigations where bird waste has accumulated within ventilation ductwork (MDPH, 1999). Significant accumulations of bird wastes have required the clean up of such buildings by a professional cleaning contractor. In less severe cases, the cleaning of the contaminated material with a solution of sodium hypochlorite has been an effective disinfectant (CDC, 1998). Disinfection of non-porous materials can be readily accomplished with a sodium hypochlorite solution. Porous materials contaminated with bird waste should be examined by a professional restoration contractor to determine whether the material is salvageable. Where a porous material has been colonized with mold, it is recommended that the material be discarded (ACGIH, 1989).

The protection of both the cleaner and other occupants present in the building must be considered as part of the overall remedial plan. Where cleaning solutions are to be used, the "cleaner" is required to be trained in the use of personal protective methods and equipment to prevent either the spread of disease from the bird wastes and/or exposure to cleaning chemicals. In addition, the method used to clean up bird waste may result in the aerosolization of particulates that can spread to occupied areas via openings (doors, etc.) or the ventilation system. Methods to prevent the spread of bird waste particulates to occupied areas or into ventilation ducts must be employed. Given that containment procedures warranted are similar to those used to contain the spread of renovation-generated dusts and odors in occupied areas, the cleaner should employ the methods listed in the SMACNA Guidelines for Containment of Renovation in Occupied Buildings (SMACNA, 1995). A copy of an issue of the *Centers for Disease Control Morbidity and Mortality Weekly Report* for July 10, 1998, which covers the clinic aspects as well as clean up associated with bird waste, is included as Appendix B.

School department officials reported that the building had active roof leaks and that funding for roof repair is part of a planned capital repair project. Water damaged ceiling tiles were observed in a number of areas throughout the building (Picture 10). Water-damaged ceiling tiles can provide a source of mold growth and should be replaced after a water leak is discovered and repaired.

BEHA staff examined the building exterior and observed several downspouts that were damaged and/or clogged (Pictures 11 and 12). Excessive exposure of exterior brickwork to water can result in damage over time. During winter weather, the freezing and thawing of moisture in bricks can accelerate the deterioration of brickwork and become a point of water intrusion.

Spaces between the sink countertop and backsplash were noted in several classrooms (Picture 13). Improper drainage or sink overflow can lead to water penetration of the countertop, the cabinet interior and areas behind cabinets. Like other porous materials, if these materials become wet repeatedly they can provide a medium for mold growth.

Plants were located in front of univent air intakes and/or near univent air diffusers (Pictures 2 and 3). Plants, soil and drip pans can serve as sources of mold growth. Over-watering of plants should be avoided and drip pans should be inspected periodically for mold growth. Plants should also be located away from univents, air intakes and other ventilation sources to prevent the entrainment/aerosolization of dirt, pollen or mold.

Shrubbery and other plants were also seen growing in close proximity to exterior walls (Picture 14). The growth of roots against the exterior walls can bring moisture in contact with wall brick. Plant roots can eventually penetrate the brick, leading to cracks and/or fissures in the below ground level foundation. Over time, this process can undermine the integrity of the building envelope, providing a means of water entry into the building through capillary action through foundation concrete and masonry (Lstiburek & Brennan, 2001).

Other Concerns

Indoor air quality can be negatively influenced by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants. Common combustion emissions include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers (μm) or less (PM2.5) can produce immediate, acute health effects upon exposure. To determine whether combustion products were present in the school environment, BEHA staff obtained measurements for carbon monoxide and PM2.5.

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. Several air quality standards have been established to address airborne pollutants and prevent symptoms from exposure to these substances.

The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

ASHRAE has adopted the National Ambient Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring of fresh air introduced by HVAC systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from 6 criteria pollutants, including carbon monoxide and particulate matter (US EPA, 2000a). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997). According to the NAAQS established by the USEPA, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2000a).

Carbon monoxide should not be present in a typical, indoor environment. If it *is* present, indoor carbon monoxide levels should be less than or equal to outdoor levels. Outdoor carbon monoxide concentrations were non-detectable or ND. Low levels of carbon monoxide (1-2 ppm) were measured in the hallway outside of the speech and language room (Table 1). Occupants in this room expressed concerns of boiler room odors and carbon monoxide exposure. BEHA staff detected boiler room odors and observed a significant space beneath the boiler room door. If the boiler room becomes pressurized, odors and particulates can be forced around the door and into the hallway. It is also important to note that the boilers were not operating during the assessment. During the heating season when boilers are operating, odors and/or emissions would be more prominent.

As previously mentioned, the US EPA also established NAAQS for exposure to particulate matter. Particulate matter is airborne solids that can be irritating to the eyes, nose and throat. The NAAQS originally established exposure limits to particulate matter with a diameter of 10 μm or less (PM10). According to the NAAQS, PM10 levels should not exceed 150 microgram per cubic meter ($\mu g/m^3$) in a 24-hour average (US EPA, 2000a). These standards were adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, US EPA proposed a more protective standard for fine airborne particles. This more stringent, PM2.5 standard requires outdoor air particulate levels be maintained below 65 $\mu g/m^3$ over a 24-hour average (US EPA, 2000a). Although both the ASHRAE standard and BOCA Code adopted the PM10 standard for evaluating air quality, BEHA uses the more protective proposed PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment.

Outdoor PM2.5 concentrations were measured at 43 $\mu g/m^3$. PM2.5 levels measured in the school ranged from 30 to 64 $\mu g/m^3$ (Table 1). Frequently, indoor air levels of particulates (including PM2.5) can be at higher levels than those measured outdoors. A number of mechanical devices and/or activities that occur in schools can generate particulates during normal operation. Sources of indoor airborne particulate may include but are not limited to particles generated during combustion of fuel, the operation of fan belts in the HVAC system, cooking in the cafeteria stoves and microwave ovens;

use of photocopiers, fax machines and computer printing devices, operating an ordinary vacuum cleaner and heavy foot traffic indoors.

Indoor air quality can also be negatively influenced by the presence of materials containing volatile organic compounds (VOCs). VOCs are carbon-containing substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals. For example, chemicals evaporating from a paint can stored at room temperature would most likely contain VOCs. In an effort to determine whether VOCs were present in the building, air monitoring for TVOCs was conducted. An outdoor air sample was taken for comparison. Outdoor TVOC concentrations were ND. Indoor TVOC concentrations were also ND (Table 1).

Please note, TVOC air measurements reported are only reflective of the indoor air concentrations present at the time of sampling. Indoor air concentrations can be greatly impacted by the use of TVOC containing products. While TVOC levels were ND, materials containing VOCs were present in the school. Spray-cleaning products were found on countertops and in unlocked storage cabinets beneath sinks in classrooms (Picture 15). Cleaning products contain chemicals that can be irritating to the eyes, nose and throat. One classroom contained a flammable all-purpose cleaner, which read "harmful or fatal if swallowed" (Picture 16). Cleaning products should be stored properly and kept out of reach of students. Flammable materials should be kept in a flammables locker approved by the National Fire Protection Agency (NFPA).

Several classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain VOCs, such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999), which can be irritating to the eyes, nose and throat. Photocopiers were located in a small room with no local exhaust ventilation to remove odors and excess heat. Photocopiers also produce VOCs. In addition, photocopiers can produce ozone, particularly if the equipment is older and in frequent use. VOCs and ozone are respiratory irritants (Schmidt Etkin, 1992).

Several other conditions that can affect indoor air quality were noted during the assessment. A few classrooms contained upholstered furniture. Upholstered furniture is covered with fabric that comes in contact with human skin. This type of contact can leave oils, perspiration, hair and skin cells. Dust mites feed upon human skin cells and excrete waste products that contain allergens. In addition, if relative humidity levels increase above 60 percent, dust mites tend to proliferate (US EPA, 1992). In order to remove dust mites and other pollutants, frequent vacuuming of upholstered furniture is recommended (Berry, 1994). It is also recommended upholstered furniture present in schools be professionally cleaned on an annual basis or every six months if dusty conditions exist outdoors (IICR, 2000).

Also of note was the amount of materials stored inside some classrooms. In several areas items were seen on windowsills, tabletops, counters, bookcases and desks. The large amount of items stored in classrooms provides a means for dusts, dirt and other potential respiratory irritants to accumulate. Many of the items, (e.g., papers, folders, boxes) make it difficult for custodial staff to clean. Accumulated chalk dust was also noted in some classrooms. Chalk dust is a fine particulate, which is an eye and respiratory irritant that can be easily aerosolized.

Several rooms had various objects hung from the ceiling tile system. The movement of ceiling tiles can provide a pathway for drafts, dusts and particulate matter between rooms and floors. Building occupants should refrain from hanging objects to prevent unnecessary strain to ceiling tile system.

Finally, during a perimeter inspection of the building, BEHA staff observed several bees/wasps nests on the exterior of the building. Under current Massachusetts law (effective November 1, 2001) the principles of integrated pest management (IPM) must be used to remove pests in state buildings (Mass Act, 2000). Pesticide use indoors can introduce chemicals into the indoor environment that can be sources of eye, nose and throat irritation.

Conclusions/Recommendations

In view of the findings at the time of the assessment, the following recommendations are made to improve general indoor air quality:

1. Install a digital readout thermometer in the hallway outside of the boiler room and monitor daily. Have boiler serviced to ensure adequate amount of combustion air for fuel.
2. Contact a building contractor to seal building envelope penetrations and/or a pest management consultant to remove birds' nests and wastes from the building. To prevent possible exposure to bird wastes, implement the corrective actions recommended by the CDC (CDC, 1998). To prevent possible spread of bird waste particulates to occupied areas, employ the methods listed in the SMACNA guidelines for Containment of Renovation in Occupied Buildings (SMACNA, 1995).

3. Survey classroom univents to ascertain function and determine whether an adequate air supply exists for each room. Consider consulting a heating, ventilation and air conditioning (HVAC) engineer concerning the calibration of univent fresh air control dampers throughout the school.
4. Operate all ventilation systems throughout the building (e.g., gym, auditorium, classrooms) continuously during periods of school occupancy and independent of thermostat control to maximize air exchange. To increase airflow in classrooms, set univent controls to "high".
5. Inspect rooftop exhaust motors and belts for proper function, repair and replace as necessary.
6. Remove all blockages from univents and exhaust vents to facilitate airflow.
7. Consider balancing mechanical ventilation systems every 5 years, as recommended by ventilation industrial standards (SMACNA, 1994).
8. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (e.g., throat and sinus irritations).
9. Continue with plans for roof repair/replacement. Replace any water-damaged ceiling tiles, once leaks are repaired. Examine the area above and beneath these areas for

microbial growth. Disinfect areas of water leaks with an appropriate antimicrobial. Clean areas of antimicrobial application when dry.

10. Make repairs to gutters/downspouts to direct rain water away from the building.

11. Replace missing or damaged caulking between countertops and sinks. Observe interior of cabinets for water-damage and mold growth. Disinfect with an appropriate antimicrobial where necessary.

12. Remove foliage to a minimum of five feet away from the foundation. Trim trees in rear of building that overhang the roof. Ensure univent air intakes on the exterior of the building are free of obstruction.

13. Move plants away from univents in classrooms. Ensure all plants are equipped with drip pans. Examine drip pans for mold growth and disinfect areas of water leaks with an appropriate antimicrobial where necessary. Consider moving the duplicating equipment to an area that has exhaust ventilation or examine the feasibility of providing local mechanical exhaust ventilation.

14. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.

15. Install door sweep and/or weather stripping around boiler room door to prevent the migration of odors into adjacent areas.

16. Replace any missing/damaged ceiling tiles, to prevent the egress of dirt, dust and particulate matter into classrooms. Refrain from hanging objects from ceiling tile system.

17. Consider having upholstered furniture cleaned professionally on an annual basis.

18. Clean chalkboards and trays regularly to avoid the build-up of excessive chalk dust.

19. Consider installing local exhaust vents in copy room to help reduce excess heat and odors from photocopiers.

20. Store cleaning products properly and out of reach of students. Ensure spray bottles are properly labeled in case of emergency. Remove flammable materials from classrooms and store in flammable storage locker.

21. Use the principles of integrated pest management (IPM) to rid the building. A copy of the IPM recommendations can be obtained from the Massachusetts Department of Food and Agriculture (MDFA) website at the following website: http://www.state.ma.us/dfa/pesticides/publications/IPM_kit_for_bldg_mgrs.pdf.

22. Consult "Mold Remediation in Schools and Commercial Buildings" published by the US EPA (US EPA, 2001) for information on mold and/or mold clean up. Copies of this document are available from the US EPA at: http://www.epa.gov/iaq/molds/mold_remediation.html.

23. Consider adopting the US EPA document, "Tools for Schools" (US EPA, 2000b) as a means to maintaining a good indoor air quality environment in the building. This document can be downloaded from the Internet at http://www.epa.gov/iaq/schools/index.html.

24. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. These materials are located on the MDPH's website at http://www.state.ma.us/dph/beha/iaq/iaqhome.htm.

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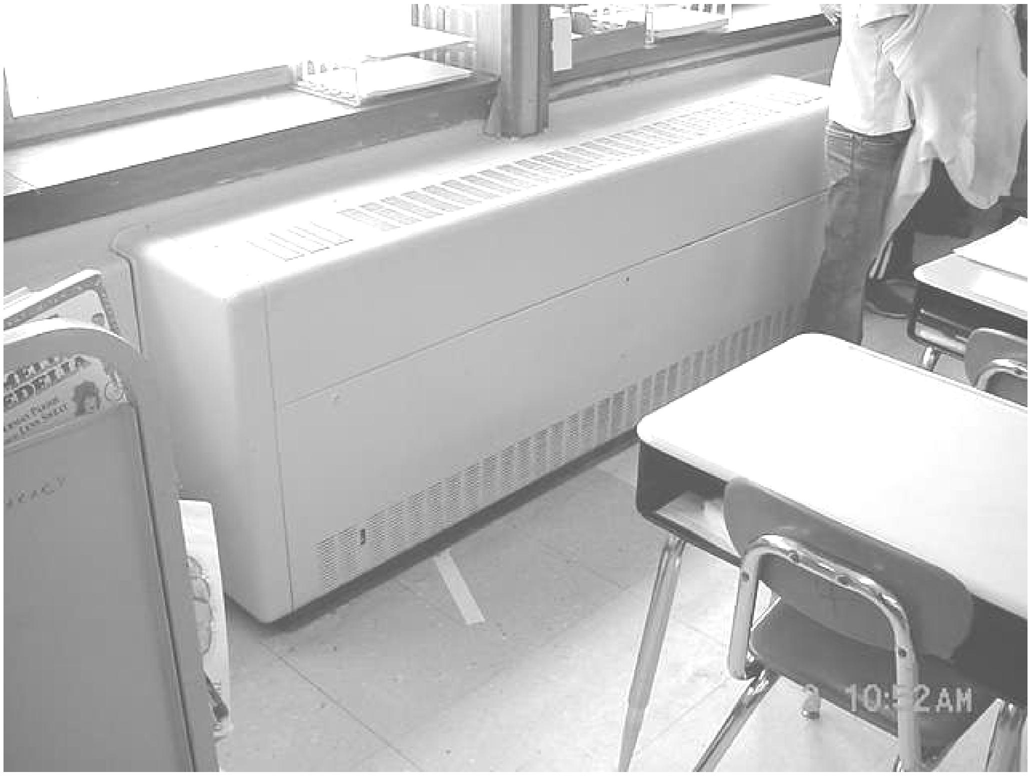
Picture 1



Classroom Univent

Picture 2

Univent Fresh Air Intake, Note Proximity of Shrubbery

Picture 3

Book Case in Front of Univent Return and Items on Top of Univent Air Diffuser

Picture 4

Exhaust Vent in top of Coat Closet

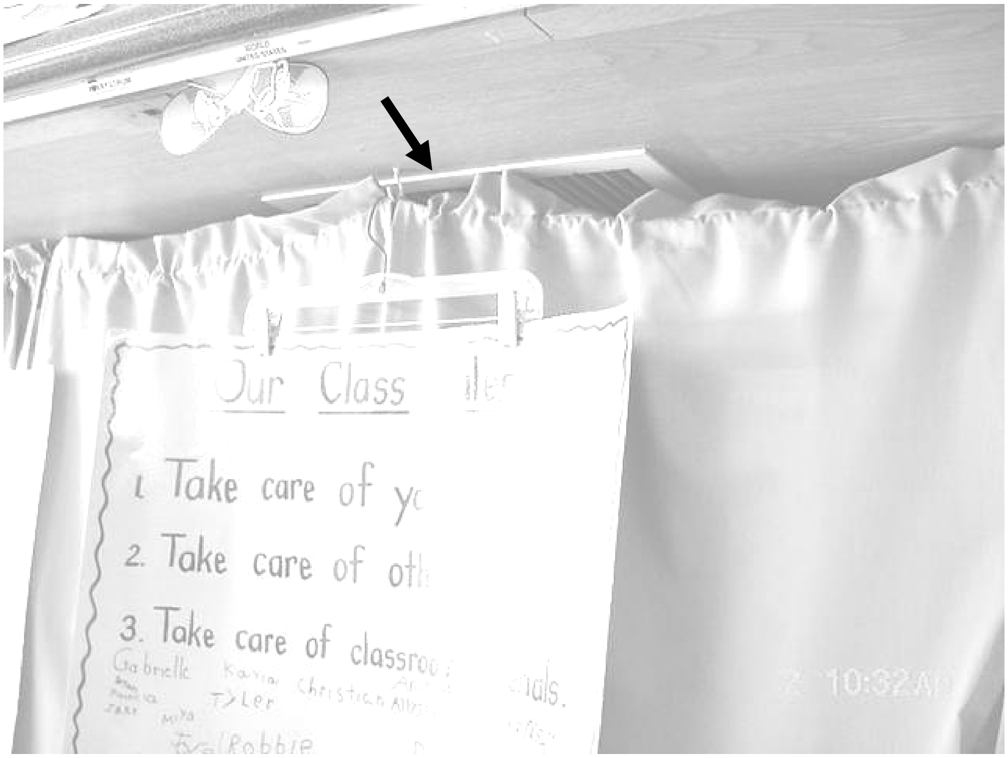
Picture 5

Undercut Coat Closet Doors

Picture 6

Obstructed Coat Closet Exhaust Vent

Picture 7



Coat Closet Exhaust Vent Obstructed by Curtain

Picture 8

Bird Nesting Materials in Roof Overhand around Downspout/Roof Drain

Picture 9

Bird Feces on Downspout and Exterior Wall

Picture 10

Water Damaged Ceiling Tiles

Picture 11

Damaged Downspout

Picture 12

Downspout Clogged With Rocks

Picture 13

Space between Sink Countertop and Backsplash

Picture 14

Trees against Exterior Walls and over Roof

Picture 15

Cleaning Products under Sink in Classroom

Picture 16

Flammable Material in Classroom Labeled Harmful or Fatal if Swallowed

Goode Elementary School | **Indoor Air Results**

31 Mayflower Ave, Middleborough MA | **June 2, 2004**

Table 1

Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
Background (Outdoors)	66	67	371	ND	ND	43	-	-	-	-	Weather Conditions: scattered clouds, winds light and variable
Teacher's Lounge	76	53	610	ND	ND	43	0	Y	N	N	Space between sink countertop and backsplash
1	78	53	798	ND	ND	48	23	Y	Y Univent	Y Closet	UV and exhaust off, UV deactivated by occupant, 1 window open
3	77	53	711	ND	ND	46	22	Y	Y Off Univent	Y	4 windows open, occupants at lunch, DEM, hallway door open
4	77	52	667	ND	ND	64	22	Y	Y Univent	Y Off Closet	1 window open, UV obstructed by furniture in front and items on air diffuser, DEM, hallway door open
15	76	56	746	ND	ND	42	21	Y	Y Univent	Y Closet	UV obstructed by clutter, aquarium/terrarium, DEM, hallway door open
14	77	58	1020	ND	ND	40	23	Y	Y Univent	Y Off Closet	DEM, 1 window open, space sink countertop/backsplash

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium
AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials
design = proximity to door
FC = food container
G = gravity
GW = gypsum wallboard
M = mechanical
MT = missing ceiling tile
NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener
PS = pencil shavings
sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
UV = univent
WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Goode Elementary School **Indoor Air Results**

31 Mayflower Ave, Middleborough MA **Table 1** **June 2, 2004**

Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
5	77	53	664	ND	ND	43	1	Y	Y Univent	Y Off Closet	CD, 20 occupants gone 65 min.,4 windows open, items hanging from CT, hallway door open
6	76	50	735	ND	ND	42	2	Y	N	Y Off Closet	Exhaust vent in closet: no passive vent or undercut door
Copy Room	79	51	667	ND	ND	39	0	N	N	N	4 photocopiers
Cafeteria	79	49	540	ND	ND	36	200 (+)	Y	Y Rooftop	Y Wall	7 windows open, hallway door open
7	79	49	513	ND	ND	40	1	Y	Y Univent	Y Off Closet	21 occupants gone 30 min., 2 windows open, UV obstructed by furniture, hallway door open
8	79	49	538	ND	ND	32	23	Y	Y Univent	Y Off Closet	Hallway door open, 5 windows open
9	78	47	408	ND	ND	30	0	Y	Y Univent	Y Off Closet	8 windows open, DEM, clutter, PF, UV obstructed by clutter and furniture, hallway

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Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Goode Elementary School

31 Mayflower Ave, Middleborough MA

Table 1

Indoor Air Results

June 2, 2004

Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
											door open
10	79	49	802	ND	ND	38	19	Y	Y Univent	Y Off Closet	1 window open, DEM, hallway door open
11	79	48	537	ND	ND	38	22	Y	Y Univent	Y Closet	4 windows open, hallway door open, UF
12	79	47	462	ND	ND	30	3	Y	Y Univent	Y Closet	DEM; hallway door open; UV obstructed by furniture
16	76	55	529	ND	ND	44	3	Y	Y Off Univent	Y Closet	Hallway door open, DEM, space sink countertop/backsplash, cleaning products
17	75	55	578	ND	ND	39	0	Y	Y Univent	Y Closet	DEM; occupants at lunch, aquarium with standing water, hallway door open
18	73	54	382	ND	ND	42	1	Y	Y Off Univent	Y Closet	Hallway door open, DEM, space sink countertop/backsplash, 25 occupants gone 30 min., 3 windows open

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Goode Elementary School | **Indoor Air Results**

31 Mayflower Ave, Middleborough MA | **June 2, 2004**

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Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
19	75	57	860	ND	ND	43	22	Y	Y Univent	Y Closet	DEM, UV obstructed by furniture, hallway door open, exhaust blocked by curtain
20	76	56	632	ND	ND	43	21	Y	Y Univent	Y Closet	DEM, 1 window open, UV obstructed by clutter, exhaust blocked by curtain, hallway door open
21	75	56	750	ND	ND	42	22	Y	Y Univent	Y Closet	Flammable material near sink, cleaning products, hallway door open, space sink countertop/backsplash
22	74	54	425	ND	ND	39	0	Y	Y Univent	Y Closet	Occupants at lunch, 2 windows open, hallway door open, space sink countertop/backsplash, plants on UV
23	76	53	689	ND	ND	41	0	Y	Y Univent	Y Closet	DEM, UV obstructed by furniture, hallway door open, exhaust blocked by clutter, space sink countertop/backsplash
24	77	53	765	ND	ND	44	9	Y	Y Univent	Y Closet	Hallway door open; space sink countertop/backsplash, CD, PF

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									Supply	Exhaust	
25	77	55	891	ND	ND	43	23	Y	Y Univent	Y Closet	DEM, UV obstructed by furniture/clutter/plants, hallway door open, exhaust blocked by clutter, space sink countertop/backsplash, cleaning products
26	78	55	893	ND	ND	55	20	Y	Y Off Univent	Y	Hallway door open, DEM, UV obstructed by furniture, hallway door open, space sink countertop/backsplash, items hanging from CTs, cleaning products
Speech & Language Room	80	50	685	1-2	ND	38	6	N	Y Passive Door Vent	N	Occupant concerns of CO/odors from boiler room, hallway door open
Boiler Room/ Hallway outside boiler room				1-2		32					Spaces underneath boiler room door

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Goode Elementary School **Indoor Air Results**

31 Mayflower Ave, Middleborough MA **Table 1** **June 2, 2004**

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Title 1 Office	78	47	450	ND	ND	32	1	Y	Y Passive door vent	N	2 windows open
Title 1	78	46	520	ND	ND	37	1	Y	N	Y Off Wall	Local exhaust vent in wall-off, DEM, hallway door open

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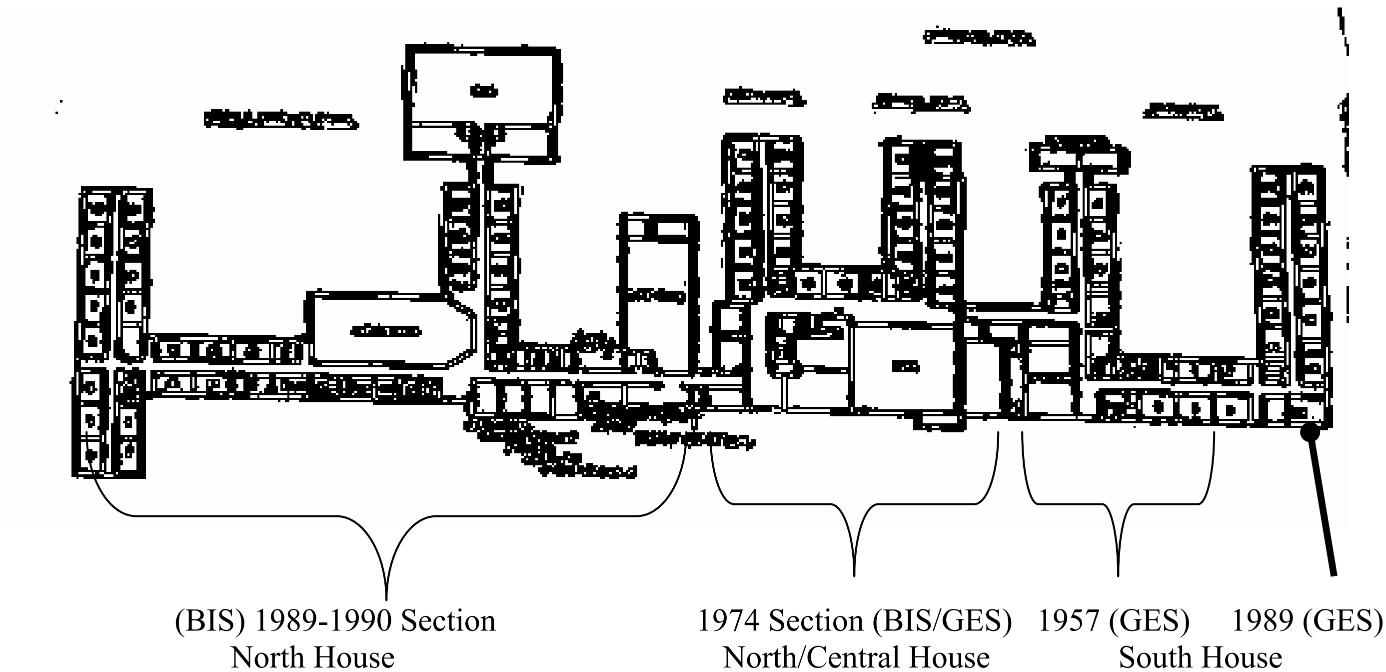
Map 1



Aerial View of Henry Burkland Intermediate School (BIS)/Mary Goode Elementary (GES) School Complex